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Specific Gravity Variation with Height in Black Hills Ponderosa Pine

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Average specific gravity decreased with increasing height up the merchantable stem. The mature trees with d.b.h. 11.0 inches or less had the highest specific gravity at all stem levels. The table presented provides a means of predicting specific gravity at different relative heights of the merchantable stem.

Keywords: Pinus ponderosa, tree specific gravity, tree merchantable height.

Specific gravity is related to many properties of wood, such as strength and pulp yields (Markwardt and Wilson 1935, U.S. Forest Products Laboratory 1953). This characteristic of wood has been widely accepted as one of the major criteria for estimating wood quality, and is reported in the literature for most tree species in the United States.

Specific gravity varies, however, both between and within trees of the same species. Average specific gravity for ponderosa pine (Pinus ponderosa) trees generally decreases with increasing height up the stem (Conway and Minor 1961, Cockrell 1943). The effect of height upon specific gravity is especially important when considering multiproduct uses of the total stem. Because the upper portions of the stem have lower average specific gravity, they will produce wood with lower strength and lower yields of pulp per cubic foot.

This report describes how specific gravity varies with height in the merchantable stem of Black Hills ponderosa pine.

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Methods

Data were collected from 226 trees sampled in earlier studies throughout the Black Hills of South Dakota and Wyoming (Landt and Woodfin 1959, Yerkes 1966). The sample trees (table 1) were separated into three groups: (1) all trees with d.b.h. greater than 11.0 inches, (2) mature trees with d.b.h. 11.0 inches or less, and (3) immature trees with d.b.h. 11.0 inches or less. Landt's study (1959) showed that the specific gravity of mature trees 11.0 inches d.b.h. or less was significantly higher than that of immature trees in that size class.

Specific gravities of the saw-log trees were determined from 12 mm diameter increment cores from heartwood and sapwood at the stump and near saw-log bucking points. The trees were bucked to a nominal 8-inch top. Specific gravities of the trees 11.0 inches d.b.h. or less were determined from wedge-shaped pieces of combined heartwood and sapwood cut from 1-inch disks at 100-inch intervals from the stump to a nominal 4-inch top. Specific gravities for all trees were calculated on the basis of green volume and ovendry weight.

Specific gravity versus merchantable height was fitted with power curves because specific gravity decreased most rapidly near the base and least rapidly near the top. The calculated regression curves were asymtotic to the X axis.

Table 1.--Growth characteristics of sample trees

	Height		Growth rate	Age	Heartwood volume
	Total	Merchantable			
	Feet		Rings/inch	Years	Percent
D.b.h. 11.0 inches or less:					
Mature					
Average	51.0	32.0	35.0	132.0	16.1
Maximum	73.0	49.0	58.0	227.0	88.4
Minimum	30.0	17.0	20.0	78.0	0.0
Immature					
Average	44.0	27.0	17.0	69.0	3.6
Maximum	67.0	49.0	26.0	90.0	33.4
Minimum	30.0	17.0	10.0	42.0	0.0
D.b.h. above 11.0 inches:					
Average	66.0	44.1	17.0	150.0	12.9
Maximum	85.0	69.1	32.0	236.0	49.2
Minimum	44.0	22.5	7.0	70.0	0.7

Preliminary analysis of the data indicated that it would be misleading to compare specific gravities at absolute heights between trees of differing merchantable heights. To overcome this problem, the heights of the sampling points were changed to a proportion of merchantable height, and the corresponding specific gravities to relative specific gravities. The relative specific gravities were calculated by dividing the specific gravity at each sampling point by the specific gravity at 1 foot for each tree. Relative specific gravities at various proportions of merchantable height were fitted for the three classes of trees (table 2). Calculated specific gravities at various proportions of merchantable height are shown in table 3.

Table 2.--Regression equations to estimate relative specific gravity from proportion of merchantable height

Tree and wood characteristics	Number of trees in sample	Regression equation	Standard error	Correlation coefficient
D.b.h. 11.0 inches or less:				
Mature	47	$y = 0.87 \times^{-0.038}$	0.0019	-0.58
Immature	104	$y = 0.90 \times^{-0.031}$	0.0013	-0.53
D.b.h. above 11.0 inches:				
Weighted heartwood-sapwood	75	$y = 0.87 \times^{-0.036}$	0.0020	-0.58
Sapwood only	75	$y = 0.88 \times^{-0.035}$	0.0019	-0.56
Heartwood only	75	$y = 0.91 \times^{-0.023}$	0.0040	-0.22

Table 3.--Specific gravity at different proportions of merchantable heights[1/] for three classes of sample trees

Proportion of merchantable height[1/]	D.b.h. 11.0 inches or less		D.b.h. above 11.0 inches		
	Mature	Immature	Weighted heartwood-sapwood	Sapwood only	Heartwood only
0.01	0.48	0.44	0.44	0.43	0.49
.05	.45	.42	.41	.40	.48
.10	.44	.41	.40	.39	.47
.15	.43	.41	.40	.39	.47
.20	.42	.40	.39	.38	.46
.25	.42	.40	.39	.38	.46
.30	.42	.40	.39	.38	.46
.35	.42	.39	.38	.38	.46
.40	.41	.39	.38	.38	.46
.50	.41	.39	.38	.37	.45
.60	.41	.39	.38	.37	.45
.70	.40	.39	.37	.37	.45
.80	.40	.38	.37	.37	.45
.90	.40	.38	.37	.36	.45
1.00	.40	.38	.37	.36	.45

[1/] Calculated as follows: Average specific gravity at 1 foot times fitted relative specific gravity at particular proportion of merchantable height.

Results and Conclusions

The immature trees with d.b.h. 11.0 inches or less have the same or slightly greater specific gravity as all trees with d.b.h. above 11.0 inches at all percentages of merchantable height (table 3). It is felt that difference in measuring technique (wedges versus increment cores weighted by volume of sapwood and heartwood) may attribute to the differences in specific gravity of the two above classes of trees. The mature trees with d.b.h. 11.0 inches or less have a higher specific gravity than either the immature trees or all trees with d.b.h. above 11.0 inches. Although the specific gravity of the heartwood for the trees with d.b.h. above 11.0 inches is considerably higher than that for the sapwood, the weighted specific gravity is only slightly higher because of the small volume of heartwood. The presence of extractives would contribute to both higher and more variable specific gravity values found in the heartwood.

The correlation coefficients of the regression equations to estimate relative specific gravity from proportion of merchantable height indicated a better or nearly as good a fit in some cases as did curves relating specific gravity to either absolute or proportion of merchantable height. Thus, the specific gravity at any point along the merchantable stem of trees with different total heights can be determined from table 3.

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